Bread Analysis;

BY

WANKLYN,

AND

COOPER.

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A PRACTICAL TREATISE

ON THE

EXAMINATION OF FLOUR AND BREAD,

BY

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LONDON:

Published by the Authors at 7, Westminster Chambers, London, S. W.

1881.

20963

M16424

PRINTED AT CARTWRIGHT'S OFFICE,

LEEK, STAFFORDSHIRE.

PREFACE.

This book was intended primarily for the Public Analyst. It has been somewhat delayed owing to various circumstances, and now reflects the results of wide experience extending over many years.

At the same time, although technical details interesting only to a very limited class of readers find their natural place in a book of this description, yet the general subject must be generally interesting. An endeavor has, therefore been made to adapt the book to the wants

of a wider public, and Chapters I and VI have been thrown into their present shape with that object in view.

In point of time this book is the first of its kind; its forerunner was the section entitled "Flour and Bread" published by one of us in the *Manual of Public Health*, in the year 1874.

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London, *S.W.*

1*st*, *March*. 1881.

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BREAD-ANALYSIS.

CHAPTER I.

FLOUR—ITS COMPOSITION; DESCRIPTION OF ITS CONSTITUENTS: BREAD.

FLOUR is composed mainly of starch-granules and gluten, the starch-granules being the more abundant but the gluten being said to be the more important.

Wheat owes its predominance over other grain to the superiority of its gluten for bread-making. Fine wheaten flour, which is the flour commonly to be bought in this country, has the following composition—

Water	16·5
Ash	0·7
Fat	1·5
Gluten	12·0
Vegetable Albumen ...	1·0
Modified Starch ...	3·5
Starch-Granules ...	64·8
	100·0

The Water is, for the most part, associated with the starch forming a sort of hydrate of starch. On exposure of flour to the temperature of the water-bath (212° Fah.), three quarters of the water are readily liberated, but the remainder only with difficulty. Flour which has been deprived of water by being maintained for some time at 212° Fah., will attract moisture from the atmosphere when it is freely exposed at common temperature and under ordinary conditions. A quantity of flour, which had been dried at 212° Fah. in the laboratory, recovered water by an exposure of 48 hours at a temperature of 60° Fah. In this experiment the recovery was almost complete, and after the lapse of 48 hours the flour weighed almost as much as it did before the drying was commenced. In good flour the water is latent and does not render the flour sensibly damp.

The Mineral Matter or Ash.—When flour is burned it leaves behind it a small quantity of fixed matter which refuses to burn away. This is the mineral matter or ash, and amounts to about 0·7 per cent. of the flour. The ash of flour is fusible at a red heat; and more than half of it consists of phosphate of potash. According to our analysis the ash of flour contains—

Phosphoric Acid P_2O_5 ...	43·7
Potash K_2O	31·8
Magnesia MgO	9·8
Lime CaO	6·0
Peroxide of Iron Fe_2O_3 and Alumina Al_2O_3	1·3
Silica SiO_2	7·4
	100·0

The Fat in flour is yellow in colour, and solid at ordinary temperatures but melting readily on being gently heated. It amounts to about 1·5 per cent. of fine wheaten flour. It is extracted by means of ether which dissolves it out of the flour. It is also soluble in alcohol of 95 per cent.

The Gluten.—When flour is moistened with a small proportion of water,—about two-fifths of its weight—it alters in physical character, and from being a fine powder, to all appearance of extreme dryness, it changes by degrees into a doughy mass. This transformation is promoted by the mechanical treatment termed kneading, and the product, which is that arising in the first stage of bread-making, is known as dough.

The change of flour into dough is due to an alteration suffered by the gluten. In the flour the gluten exists in a pulverulent condition and is comparatively—if not absolutely—anhydrous: in the dough the gluten is plastic and hydrated. In the flour the gluten is, as it were, buried by the starch-granules which far exceed it in quantity: in the dough the starch-granules are buried in the gluten which has entered into combination with water and formed a hydrate which almost exceeds the starch-granules in point of quantity. Dough is plastic hydrated gluten enclosing starch-granules, and by a process of washing the starch-granules may be separated from the gluten.

Hydrated gluten has some very peculiar properties. It appears to be absolutely insoluble in water, and does not adhere to moist surfaces. Presented to a dry surface—to dry filter paper, or to a dry metallic surface, for instance,—it adheres most obstinately. A surface of plastic gluten adheres to another surface of gluten when presented to it. In this

respect hydrated gluten is like burnt india-rubber: whilst dough, which as has been explained, is hydrated gluten laden with starch-granules, resembles plastic clay. The plant is purveyor to the animal, and in gluten the cereal makes its offering of the organic clay out of which flesh is formed.

Gluten was first obtained from flour by Beccaria and chemists were very early impressed with the connection between it and animal substances. In old chemical books (we have before us a book dated 1813) gluten is described as "exhibiting to chemical analysis all the properties of animal matter:" and when, in after years, accurate quantitative analysis enabled a comparison to be instituted between the ultimate composition of gluten and egg-albumen chemists perceived that these substances have identically the same percentage composition.

The following is the analysis* of gluten (anhydrous)—

Carbon . . .	52·6
Hydrogen . . .	7·0
Nitrogen . . .	16·0
Oxygen (with traces of Sulphur)	24·4
	100·0

Not only in ultimate percentage composition is gluten identical with albuminous substances of animal origin, but identity is indicated by proximate analysis—by limited oxidation and other methods of investigating chemical structure.

Hydrated plastic gluten prepared from flour, as above described, is not perfectly white. It is straw coloured with a shade of grey; and it is somewhat variable in colour, depending on the quality and soundness of the grain from which the

*This analysis is compiled from well-known sources.

flour is made. The other physical properties of the hydrated gluten are also subject to some degree of variation depending on the quality of the grain.

Hydrated gluten loses its water on prolonged exposure to a temperature of 212° Fah. and dries up into a "brittle semi-transparent substance which looks not unlike glue and in drying, it strongly adheres to the substance on which it rests." If the hydrated gluten be spread out in a thin layer over the surface of a platinum dish it may be rendered perfectly anhydrous by an hour's exposure to a temperature 212° Fah.

Gluten which has once been made to pass from the hydrated to the anhydrous condition cannot a second time be rendered plastic.

Gluten—whether hydrated or anhydrous—is, as has been said, insoluble in water. It is equally insoluble in ether and absolute alcohol. Like albumen it appears to be a weak organic acid and dissolves in alkalies. In very dilute solutions containing acids it also dissolves in course of time.

It does not very readily suffer destructive changes and may be heated to 300° Fah. without sensible alteration. On raising the temperature much higher, as an old author wrote, it "shrinks and coils up like most other of the soft animal substances, then melts and takes fire, burning with the fetid odour of animal matter."

Gluten is not a single chemical substance but a mixture of several chemical substances. A portion of gluten is soluble in weak alcohol but the major part is insoluble. So far, as is known, all the different substances comprised by gluten are closely allied substances with many essential properties in common.

Vegetable Albumen. When flour is made into dough (as just

described) and when the dough is washed with cold water, the aqueous liquid in which the starch-granules are suspended dissolves a certain quantity of albuminous substance presenting the closest likeness to soluble egg-albumen. The substance is coagulable when the liquid is warmed, precipitable by means of nitric acid and is hardly distinguishable from common egg-albumen. The proportion of this soluble vegetable albumen in flour is about 1·0 per cent. and the function of the soluble albumen is to act as a ferment.

Modified Starch. The cold aqueous solution just mentioned contains a small quantity of maltose and dextrine which owe their existence to the transformation of broken-down starch-granules by the action of the vegetable albumen which at the moment of moistening the flour effects an instantaneous transformation into these products. In sound flour these products are very small viz., some 3·5 per cent. In unsound flour, or flour broken down by trituration with powdered glass a larger proportion is to be looked for

The Starch-Granules, which amount to about two-thirds of the weight of the flour, may be washed out of the dough by kneading it with successive portions of cold water. The aqueous liquid in which the starch-granules are suspended deposits most of them very readily on being left at rest, and after the lapse of an hour or two leaves a firm layer of starch-granules at the bottom of the vessel. The supernatant liquid may then be poured off and the starch-granules after a little washing allowed to dry at ordinary temperatures and afterwards dried in the water-bath and weighed. In this manner we have measured the percentage of starch-granules in flour; 64·8 being the mean of two analyses of different samples of flour. The operation is tedious from the great length

of time required in order to obtain a perfectly clear supernatant liquid. In our experiments the quantity of flour operated upon was 10 grammes: and instead of waiting for perfect clearness of the supernatant liquid we poured it off whilst still slightly turbid and supplemented the decantation by filtration, and ultimately weighed a small portion of the starch in contact with a small filter paper which had been counterpoised beforehand.

Dried masses of wheaten starch-granules constitute one of the commonest forms of commercial starch. They are prepared by essentially the same process as that just described only the starting point is not the flour, but the unground grain, and the product is airdried. The most salient properties of these masses of starch are familiar to most persons. Such starch has a fine white colour, and is usually concreted in longish masses; it has scarcely any smell, and very little taste. Its specific gravity is 1·5. It does not dissolve in cold water, nor in alcohol, nor in ether. When kept dry it is a very permanent substance and is uninjured by prolonged exposure to the action of the atmosphere.

The structure of the individual starch-granules has been very elaborately investigated. The granules are composed of concentric layers of "granulose" and "starch-cellulose." The outer layers of the granule are denser and more hydrated than the inner layers: and the extreme outside layer is starch-cellulose absolutely devoid of granulose.

There is no difference between the starch-cellulose and the granulose in ultimate chemical composition and these substances are closely allied and have much in common. But starch-cellulose is insoluble and inert, whilst granulose is soluble and active towards malt-extract. The peculiar structure

of the starch-granule with its outside impermeable starch-cellulose which limits and isolates the granule explains the properties of starch-granules.

When starch-granules are placed in cold water they become more or less distended by absorption of the water which passes through the outside layers of the granules. Apparently some of the granulose enters into solution, but this solution is absolutely limited by the layer of starch-cellulose which isolates it and cuts it off from the water in which the granules are floating. So long as the starch-granules are unbroken they are absolutely insoluble in cold water.

Starch-granules when air-dried retain some 18 per cent. of water which is lost on drying at 212° Fah. and reabsorbed on exposure to the atmosphere.

Anhydrous starch is most simply represented by the chemical formula $C^6 H^{10} O^5$ and has the following ultimate composition—

Carbon	72	...	44·44
Hydrogen	10	...	6·17
Oxygen	80	...	49·39
	162		100·00

Thus starch is a Carbo-hydrate, that is to say its hydrogen and oxygen are present in the proportions requisite to form water. The common vegetable substances, cellulose, woody-fibre, dextrine and starch have the same percentage composition. The formula which has just been given is the simplest possible expression but, as has been often remarked by ourselves and others, the true formulæ for these substances are, no doubt, much larger and more complicated.

Action of Iodine on Starch. In the year 1813 Stromeyer

discovered the now very familiar blueing of starch by means of iodine. This, which is one of the most characteristic reactions of starch, is best observed by pouring weak solution of free iodine into water containing starch-paste. The striking and beautiful indigo-blue colour which is seen in this experiment is produced only when the iodine is in the free state, or in the weakest of combinations, such as the combination of iodine with solution of iodide of potassium. Neither hydriodic acid nor iodide of potassium, nor iodic acid, nor chloride of iodine gives the blue colour with starch. A solution of sulphurous acid removes the blue colour by reason of its causing the free iodine to unite with nascent hydrogen arising from the decomposition of water. Alkalies also decolourise blue iodide of starch by reason of their action on the iodine. As we have just said the blue colour is most conveniently obtained by the use of starch-paste. We have further to remark that granulose gives the blue, that intact starch-granules are made blue by solution of iodine which penetrates through the layer of starch-cellulose and colours the contents of the starch-granule, but not the outside liquid, and that un-modified starch-cellulose does not give blue with iodine. On the other hand modified starch-cellulose gives blue with iodine.

When starch-granules diffused in water are gradually heated in contact with the water they swell enormously and at length, as the temperature reaches the boiling point of water, they burst with the formation of starch-paste. The degree of viscosity of starch-paste is very variable and depends upon a variety of causes. When starch-paste has been boiled not only the granulose but the starch-cellulose itself becomes capable of blueing iodine: and indeed the

starch-cellulose loses its inertness altogether by this operation.

Action of dilute soluble albumen or malt-extract. Soluble starch or starch-paste, but not intact starch-granules, are instantaneously transformed by the solution of the vegetable-albumen or by malt-extract. The products of this transformation are two and two only, viz., maltose and dextrine. The simplest expression of the change is the following equation:—

$$\underset{\text{starch}}{C_{18}H_{30}O_{15}} + H_2O = \underset{\text{dextrine}}{C_6H_{10}O_5} + \underset{\text{maltose}}{C_{12}H_{22}O_{11}}.$$

The action of dilute acids, although analagous, is somewhat different, viz.,—

$$\underset{\text{starch}}{C_{18}H_{30}O_{15}} + 2H_2O = \underset{\text{dextrine}}{C_6H_{10}O_5} + \underset{\text{glucose}}{C_{12}H_{24}O_{12}}.$$

It is furthermore to be noted that there is a completeness about the action of dilute acids which does not appertain to malt-extract. The dilute acid acts on the residual dextrine and causes it to combine with water and so brings about an utter convertion of the whole of the starch into glucose. After the completest possible action of malt-extract some dextrine still survives, but no dextrine survives the complete action of the dilute acid.

Maltose and glucose yield alcohol and carbonic acid on fermentation: both also reduce oxide of copper though in different proportions.

Differences between the starch-granules of different plants.—Starch-granules are microscopic objects differing much in size according to the plant from which they are derived. The following are the measurements of different kinds of starch granules:—

Potato . .	0·185 to 0·140	Millimetre.
Sago .	0·070	„
Broad bean . .	0·075	„
Pea . .	0·050	„
Wheat . .	0·050	„
Maize . .	0·030	„

The different kinds of starch may be identified by their microscopic characters. This is practicable when the starch is unmixed; but mixtures of different starches are difficult of recognition. In cases of this kind a partial separation of starches may be made by taking advantage of the varying rates of subsidence from suspension in water. The large granules of potato-starch subside much quicker than the smaller varieties of starch-granule, and, by taking advantage of this property, a small quantity of potato-starch may be separated from wheaten starch and identified by its microscopic characters. Granules of potato-starch are more easily ruptured than granules of wheaten starch.

The ultimate or elementary composition of fine wheaten flour admits of calculation, thus—

			C	H	N	O
Water -	16·5	=	...	1·89	...	14·61
Ash -	0·7	=	...	...	...	...
Fat -	1·5	=	1·16	0·18	...	0·16
Gluten &c.	13·0	=	6·838	0·91	2·08	3·172
Starch &c.	68·3	=	30·352	4·214	...	33·733
	100·0		38·350	7·194	2·08	51·675

And collecting the figures in convenient tabular form we have—

Percentage composition of fine wheaten flour in its ordinary air-dried condition—

Carbon	.	38·350
Hydrogen	.	7·194
Nitrogen	.	2·080
*Oxygen	.	51·675
Ash	.	0·701
		100·000

BREAD.

Bread is made when flour is converted into dough and rendered vesicular and baked.

The manner in which this is accomplished, as well as the exact practical details, are subject to some degree of variation.

I quote the following from an old book, date 1813 :—

"Mr. Dossie, who appears to have paid great attention to the art of baking, gives the following simple and much approved method of making good white bread : take of fine flour, six pounds ; of water, moderately warm, but not hot, two pints and a half; of liquid yeast, eight spoonfuls; and of salt, two ounces. Put about a pint of warm water to the yeast, and mix them well, by beating them together with a whisk. Let the salt be put to the remaining part of the water, and stirred till completely dissolved. Then put both quantities of the fluid gradually to the flour, and knead the mass well till the whole is properly mixed. The dough thus made must stand four or five hours, that is till the exact moment of its being fully risen, and before it is sensibly perceived to fall. It is then to be formed into loaves and immediately placed in the oven. To bake it properly, is

*Including trace of sulphur.

attended with some difficulty to those who are not skilled in the art. The first care is to see that the oven be sufficiently heated, yet not to such a degree as to burn the crust. If a green vegetable turns black when put in, the oven will scorch the bread; in which case it must stand open till the heat has somewhat abated. The next circumstance to be attended to is, that the mouth of the oven be well closed, till the bread has risen to its full height, which will not take place in less than two or three hours. After this, but not before, the oven may be opened for the purpose of viewing the bread, and seeing that it is baked without being either burnt or too crusty; for if the mouth of the oven be not kept closely stopped till the bread is fully risen, it will flatten and become heavy. When properly managed, the above mentioned ingredients will have lost about one pound two ounces in weight, so that a well-baked loaf of this kind should amount to seven pounds twelve ounces."

The modern reader will be puzzled with the arithmetic, and will require to be reminded that the "Two pints and a half of water" must be read as $2\frac{1}{2}$ lbs. of water. Thus we have—

	lbs. oz.
Flour . .	6 „ 0
Water . .	2 „ 8
Yeast . .	0 „ 4
Salt	0 „ 2
	8 „ 14
Loss in baking	1 „ 2
	7 „ 12

From this quotation we may arrive at the quantity of moisture to be expected in well-made bread. Bearing in mind that the flour contains 16·5 per cent. of moisture and making the calculation on these data we find that the bread should contain 33 to 34 per cent. of water.

Instead of employing yeast to set up the fermentation of the maltose in the dough other means are sometimes resorted to: thus fermenting dough may itself be used for the purpose of causing fresh dough to ferment.

In unfermented bread the dough is rendered vesicular by addition of carbonic acid gas under pressure.

As to the composition of bread, the remark may be made that the starch-granules should be, for the most part, intact: and the following approximate tabular statement will serve:—

In 100 parts of bread—

Water	34·0
Ash	2·0
Gluten	9·5
Starch-Granules with some altered starch	54·5
	100·0

An experiment was made with the object of ascertaining to what extent the starch-granules had undergone destruction. The result arrived at was—that, in 100 parts of bread, there were 5 parts of modified starch-granules, and that the 5 parts consisted partly of soluble starch.

CHAPTER II.

THE WATER IN BREAD.

The determination of the water in flour does not, in an especial manner, call for the attention of the Public Analyst, but the determination of the water in Bread is of great importance, and the varying amounts of water in the Bread of commerce deserve to be prominently brought forward.

As has been set forth in the first chapter well-made bread should contain some 34 per cent. of water, and the bread-solids in well-made bread will thus amount to 66 per cent.

The bread to be met with in the market contains sometimes 40 per cent. of water, and even much more than 40 per cent. of water.

When bread contains 40 per cent. of water the Bread-solids amount to 60 per cent. : and the baker who supplies such bread instead of what may be designated as normal bread accomplishes the profitable commercial operation of making 60 lbs. of bread-solids do duty for 66 lbs. of bread-solids.

History informs us that the baker has generally been looked on with some degree of suspicion and that, in former times, the law dealt with him with great severity when he gave short weight. For supplying bread which was one ounce short in thirty-six ounces the baker used to be put into the pillory ; and, in the early years of the present century, a fine of five shillings was imposed for that offence.

On these facts the conclusion is irresistible that all legislation relative to the short weight of the loaf must be ridiculous unless account be taken of the degree of hydration.

Bread which is too moist is prone to grow mouldy, and some years ago a government investigation in France traced a serious outbreak of disease in the French army to the poisonous character of a quantity of too moist bread which had formed the rations.

Sanitary as well as economical considerations concur in condemning the practice of surcharging bread with moisture.

There is probably hardly any question which so much calls for the action of the Public Analyst as the question of the moisture in bread, and a standard ought to be established and appended to the Sale of Food and Drugs Act.

With this object in view we give a method of measuring the water in bread, which is practicable and efficient and which runs no risk of over-stating the amount of water.

The following is the method which we propose :—

The sample of bread is carefully deprived of the crust (which is cut away), and, that having been done, the bread is crumbled into small crumbs of about the size of mustard seeds. In order to get a fair average sample some 50 grammes of bread should be crumbled—but the actual drying is carried out on a much smaller quantity viz., on 5·00

grammes. A good sized platinum dish (weighing 50 to 100 grammes) is then charged with the 5·00 grammes of bread-crumbs which are spread out in a thin layer in the dish. The dish with its contents is then transferred to the water-bath and maintained at a temperature of 212° Fah. for two hours and then it is wiped externally, cooled and rapidly weighed. The loss in weight is the quantity of water yielded by 5·0 grammes of the sample of bread and when multiplied by 20 gives the percentage of moisture in the bread.

By rigidly restricting the operation of drying to temperatures not exceeding 212°. Fah. all risk of scorching is avoided. By specifying the time viz., two hours, we save a great deal of trouble and avoid uncertainty.

Bread-crust, as might be expected, contains less moisture than the crumb. As a necessary consequence of this the figure for the moisture of the crumb will be a little larger than the figure for mixed crust and crumb. We fix 34· for the percentage of moisture in the crumb of normal bread.

In the investigation of samples of bread, from 42 bakers in Peterborough, we have had an opportunity of encountering the practical difficulties which attend this description of work; and, accordingly, we call attention to the necessity of adopting precautions to ensure that a partial drying of the bread does not occur before the analyst takes the bread in hand.

The samples of bread should not be too small, or cut into thin slices, but should be in masses—whole loaves or unbroken ovencakes answer best—and, as soon as practicable, the samples should be placed in a tin canister in which they may be preserved until the commencement of the operation of analysis. The best plan is to have a separate canister for each sample; or a canister with metallic divisions so as to

isolate each bread.

In the case of the bread from Peterborough, we have been careful to select portions of crumb from the very centre of the loaf; and the measurements of the percentage of water were made on such portions of the crumb.

The percentage of water found in the 42 samples of bread from Peterborough was as follows:—

No. 1	...	40·75
„ 2	...	39·4
„ 3	...	34·4
„ 4	...	40·2
„ 5	...	39·5
„ 6	...	37·3
„ 7	...	40·3
„ 8	...	38·7
„ 9	...	36·5
„ 10	...	35·4
„ 11	...	37·5
„ 12	...	38·4
„ 13	...	37·3
„ 14	...	40·2
„ 15	...	39·8
„ 16	...	37·8
„ 17	...	37·2
„ 18	...	35·6
„ 19	...	37·9
„ 20	...	36·3
„ 21	...	39·9
„ 22	...	41·2
„ 23	...	43·8
„ 24	...	38·8

No. 25	...	35·8
„ 26	...	37·3
„ 27	...	42·0
„ 28	...	38·9
„ 29	...	29·1
„ 30	...	34·1
„ 31	...	36·1
„ 32	...	32·7
„ 33	...	33·7
„ 34	...	31·4
„ 35	...	36·3
„ 36	...	35·7
„ 37	...	35·6
„ 38	...	38·7
„ 39	...	40·3
„ 40	...	38·9
„ 41	...	37·8
„ 42	...	38·4

Classifying these results we place together No.s 1, 2, 4, 5, 7, 14, 15, 21, 22, 23, 27, and 39. These twelve samples yielded high percentages of water, viz., from 39·4 per cent. to 43·8 per cent.

The mean percentage of water in these twelve samples of bread is 40·6.

There are likewise five more samples of bread which yielded approximately 39 per cent of water. We find, therefore, that seventeen out of the forty-two samples, or two-fifths of all the samples of bread, yielded on an average 40 per cent. of water.

There are eleven samples which yield less than 36· per cent. of water, the mean being 33·95 per cent.

We have, therefore :—

		Percentage of Water (mean)
17	High Samples	40
11	Low Samples	34
14	Intermediate	
42		

We will assume that the condition of the bread supplied by the bakers of Peterborough affords a fair representation of the bread supplied generally throughout England.

We have already called attention to the fraud on the Public which is involved in the supply of bread surcharged with water. This question should be taken up by Parliament. We now revert to the Sanitary aspect of the subject.

The samples of bread from Peterborough exhibited an astonishing tendency to grow mouldy ; No. 1, for instance, became mouldy, on being kept in a tin canister for three days; and, in five days, most of the samples became horribly mouldy. Unfortunately we did not take the requisite precautions to ascertain by direct observation whether or not the degree of mouldiness ran parallel with the degree of hydration.

There is, however, good reason for believing that (although other causes, as for instance the deficiency of salt, no doubt, concur) the degree of hydration is one of the main factors in the case.

The notorious instance of poisonous rations supplied to the French army in the year 1843, lends support to the view that fungoid growths in bread are favoured by excessive hydration. According to Payen the percentage of water in the

crumb of the bread, which was supplied to the French army, was 50, and the connection between the fungus and the excess of moisture was held to be established.

Invalids and other persons whose digestive organs are delicate, should be supplied with bread which has been especially well baked: and indeed, as has been already said, there is nothing connected with bread which so emphatically demands attention as this question of the percentage of water.

The occasional occurrence of fungoid growths in bread is a subject which calls for the attention of the Medical Officer of Health, and suggests the question—whether the mortality among young children does not, in some instances, resolve itself into a case of wholesale poisoning by unwholesome Fungi.

CHAPTER III.

THE ASH OF FLOUR AND BREAD. MINERAL ADULTERATION OF FLOUR AND BREAD——ALUM.

As already mentioned in Chapter I, the ash of flour is about 0·7 per cent.

The following determinations, made on well authenticated samples, exhibit the amount of ash in different kinds of flour.

			Percentage of Ash.
Fine Flour Sample	No. 1	gave	0·73
„ „	No. 2	„	0·75
„ „	No. 3	„	0·74
„ „	No. 4	„	0·89
„ „	No. 5	„	0·66
„ „	No. 6	„	0·62
„ „	No. 7	„	0·62

			Percentage of Ash.
Flour from Cambridgeshire,	No. 8	gave	0·52
„ „ „	No. 9	„	0·62
Hungarian Flour	No. 10	„	0·40
„ „	No. 11	„	0·37
„ „	No. 12	„	0·37
Australian Flour	No. 13	„	0·54
Vienna Flour	No. 14	„	0·36
Californian Flour	No. 15	„	0.83
American Flour	No. 16	„	0·60
„ „	No. 17	„	0·43
Unsound Calcutta Flour	No. 18	„	1·11
Rivet Cones	No. 19	„	0.89
„ „	No. 20	„	0·95

The reader's attention will be attracted by the singularly low ash of the Hungarian flour, and of some varieties of American flour. The unsound Calcutta flour with the high ash had been damaged by sea water.

Various causes influence the exact proportion of ash in flour. Besides possible variation in the grain itself and variation depending on the degree of fineness of the flour, there is the slight degree of contamination arising from the wearing down of the mill-stone. This shonld be exceedingly minute in extent but cannot be absolutely avoided. Wearing down of the stone would tend to increase the silica in the flour, also the lime and the silicate of alumina.

A number of samples of fine flour have been examined in the laboratory with the special object of noting the amount of mixed phosphates of alumina and iron.

The following are the results, which for convenience are stated on 100 grammes of air-dried flour.

Number of grammes yielded by 100· grammes of the flour.

	Silica and Sand.	Phosphate of Iron and of Alumina.
No. 1.	0·046	0·016
No. 2.	0·070	0.018
No. 3.	0·038	0.012
No. 4.	0·046	0·016
No. 5.	0.020	0·010
No. 6.	0·044	0·014
No. 7.	0·040	0·012
No. 8.	0·044	0·020

The first seven samples of flour were from London dealers: sample No. 8 came from Buckinghamshire.

The smallness of these proportions deserves to be noted: 100,000 parts of flour contains from 20 to 70 parts of Silica and sand, and from 10 to 20 parts of "Phosphates insoluble in acetic acid. The wearing down of the millstone is measured by figures within than these quantities.

The Ash of Bread must contain the ash of the flour from which the bread was made, the ash of the yeast, and the mineral matter contained in the water added to the flour in the operation of bread-making, and lastly and chiefly, it must contain the common salt which is also added during that operation.

The following determinations have been made in the laboratory.—100 grammes of different samples of bread yielded :—

	Bread-Ash.	Silica and Sand.	Phosphates of Iron and Alumina
	grammes.	grammes.	grammes.
Sample A	1·408	not taken	·010
„ B	1·378	not taken	·006
„ C	1·730	·018	·010
„ D	1·620	·032	·014
„ E	1·383	·030	·012
„ F	0·890	·021	·006
„ G	1·742	·024	·008
„ H	1·600	·045	·011

The main constituent of Bread-ash is Chloride of Sodium; and the main cause of the variation in the quantity of ash yielded by different samples of bread is the varying quantity of salt which the baker puts in during the bread-making. In burning up a quantity of bread so as to get the ash, the impossibility of effecting complete combustion without volatilizing some of the salt must necessarily cause the total ash, as weighed, to be somewhat below the truth. (If, for any purpose, a very accurate determination of the bread-ash in any given sample of bread were required, the direct determination of the ash, by combustion and weighing of the residue, would have to be supplemented by a partial burning of the bread and a determination of the Chlorine in the solution obtained by boiling the partially burnt bread-ash with water.)

Mineral Adulterations of Flour and Bread. The mineral adulterations fall into three categories, viz.,

(1) gross mineral adulteration for the purpose of gain:

(2) small mineral adulteration through negligence in manufacture:

(3) adulteration for the purpose of improving the flour in bread in certain respects; and we shall accordingly divide the subject in this manner.

(1) *Gross mineral adulteration for the purpose of gain.*— In ordinary seasons, in this country, flour sells for something like £20 per ton; and, assumiug that he can do so with impunity, it would pay the miller to mix with it some cheap substances such as Chalk, Plaster of Paris, Bone ash &c. Probably an admixture of 10 per cent. of such materials, and certainly an admixture of 20 per cent. would pay: but proportions much under 10 per cent. would hardly be profitable.

In the course of our practice as Public Analysts we have not met with this description of adulteration, nor have we heard of any authenticated case, and we have little doubt that at the present time this kind of adulteration is very rare.

In historical times it may have been otherwise: and, during periods of famine, it might occur. Possibly in time of war, an army contractor might find it to his interest to resort to such adulteration.

We have ourselves examined samples of flour from the poorer parts of London, from the New Cut and Seven Dials, and found no sign of any adulteration of that sort.

Although this form of adulteration is so very uncommon, yet the Public Analyst should be on the look out for it, and every examination of flour and bread should comprise either proof or disproof of its occurrence,

The detection of it is very easy; all that is necessary being a determination of Ash in the flour or bread.

The natural ash in flour, as has been seen, is 0·7 per cent. If this kind of adulteration had been practised the ash would be at least 5·0 per cent. The natural ash of bread is some

1·5 per cent.: but in a case of the kind it would rise to at least 5 per cent.

In taking the ash of flour or bread with the view of detecting such adulterations one gramme of the flour or bread may be conveniently burnt in a platinum crucible. During the course of the ignition, it will be observed that the burning takes place rapidly at first, but that after a time a hard cake is left which does not burn rapidly. Almost the only caution which it is necessary to give (and that is only necessary to a beginner) is not to mistake this cake for the ash.

Should anyone be in doubt whether he has got the cake or the ash, the doubt may be set at rest by a reignition and reweighing. Th ecake will lose greatly in weight on reignition: the ash will not.

(2) *Small Mineral Adulteration through negligence in Manufacture.*—The objection which the buyer has to this kind of adulteration is, not thāt he is buying sand for the price of flour, nor that he is being poisoned, but that he is entitled to have grain carefully ground, flour carefully sifted, and bread carefully made, and that the occurrence of this adulteration is evidence of negligence. Under the adulteration act of 1872, there is some degree of doubt whether dealers could be prosecuted for this species of adulteration, inasmuch as it cannot be maintained that the weight or bulk is sensibly increased by the presence of these minute quantities of valueless matters, and still less that the articles are rendered injurious to health. But under the new Act of 1875 there can be no doubt that this species of adulteration constitutes an offence, inasmuch as the presence of any *foreign* matter in an article of food ren-

ders the vendor liable under the new Act. It is true that there are important exceptions, that, for instance, "where the article is unavoidably mixed with extraneous matter" it may be legally sold. The exceptions, however, do not include cases where the foreign material—so far from being unavoidable—could not have been present if reasonable care had been bestowed upon the manufacture. And it appears to us that the spirit of the new Act would sanction the treatment of this second class of adulteration with some degree of rigour.

All of the flour and bread which we have hitherto examined has contained remarkably little clay or sand or material rubbed off the millstone. From this we draw the conclusion that, with ordinary care and skill, the miller and the baker find it quite practicable to produce flour and bread remarkably free from clay, sand and rubbed down millstone. And after our experience we should look upon the presence of more than minute traces of clay &c. as evidence of want of ordinary care in the manufacture. And under the provision of the Act of 1875, which makes it penal to sell an article of food containing unacknowledged foreign matter which is not unavoidably present, we think that such cases should be dealt with.

The great importance of bread to the community justifies the taking of every reasonable precaution to insure its thorough goodness and genuineness, and warrants our forbidding negligence of manufacture even if we cannot exactly specify any direct evil resulting from such negligence.

We have been at pains to exhibit the range within which the mineral constituents of good flour and bread vary. For the present purpose the following synopsis may be useful.

From 100 grammes of fine flour—

Natural or Normal.		Abnormal, being indicative of negligent manufacture.
	Grammes.	Grammes.
Total Ash	0·400 to 0·800	1·000 and over
Ash insoluble in water	about 0·300	0·600 and over
Silica & sand	0·020 to 0·070	0·100 and over

From 100 grammes of bread—

Natural or Normal.		Abnormal, or indicative of negligent manufacture.
	Grammes.	Grammes.
Total Ash	0·800 to 1·600	2·000 and over
Ash insoluble in water.	0·200 to 0·400	0·400 and over
Sand & silica	0·010 to 0·050	0·100 and over

For the purpose of making out a case of adulteration of the second class (that is to say Adulteration through negligence in manufacture) greater accuracy in the determinations of ash is requisite than is needed for the detection of adulteration of the first class, and accordingly the analyst will do well to take, for the determination of ash, ten grammes of flour or bread, instead of the one gramme as was recommended for adulteration of the first class.

(3) *Adulteration for the purpose of improving the flour or bread in certain respects.*—Under this heading comes one of the forms of adulteration which has greatly impressed the Public mind, viz., the aluming of bread—concerning which practice great misapprehensions have been prevalent.

It used to be the popular belief that bread was often adulterated with a considerable proportion of alum—with so considerable a proportion of alum that the well known con-

stipating effects of taking doses of alum were liable to be produced. There is however little foundation for this belief, since the proportions of alum actually employed are from 20 to 60 grains per 4 lb. loaf, and that would not, in presence of the phosphate existing in the bread, be a constipating dose. Not only was the magnitude of the dose and the activity of it exaggerated but the prevalence of the practice was likewise exaggerated, and we have met with persons who lived in a state of continual panic on this account. Much of these exaggerations has been due to the extremely unsatisfactory condition of the analytical methods formerly employed for the detection of this adulteration.

The object of the addition of the alum is to arrest the change in the gluten, and flour in a state of incipient unsoundness is said to be so far improved by the alum as to be rendered thoroughly capable of yielding bread in good physical condition.

The usual proportion of alum employed appears to be from 20 to 60 grains of alum per 4 lb. loaf.

On making a calculation, and calling to mind the natural constituents of bread-ash, some of the analytical difficulties will come into view.

If 28 grains of alum were put into the 4 lb. loaf the alum would be present in the bread in the proportion of 0·1 per cent. But half of alum is water of crystallisation, so that the actual quantity of mineral material which had been introduced, (the burnt alum) would amount to only about ·05 per cent. of the weight of the bread. Still more minute is the proportion of alumina, or even of phosphate of alumina, the percentage of alumina being 0·011 and that of phosphate of alumina (which is the form under which it is actually found

in bread-ash) 0·027.

Having taken, for analysis, 100 grammes of flour or bread the alum-problem consists in the separation of the 0·027 grammes of phosphate of alumina from the other constituents of the ash of the flour or bread.

We are informed that, so ill-advised and ill-instructed have some of the persons been, who have undertaken the detection of alum in flour and bread, that they have mistaken the 0·1 or 0·2 grammes of flour-ash, or bread-ash, which is insoluble in water for alumina, and have returned results in accordance with that mistake. Such persons having burnt up the flour or bread, boil the ash in acid and then add ammonia in excess and then mistake the precipitate (which is a mixture of phosphate of magnesia and phosphate of lime &c.) for alumina.

And, having made this mistake, such persons would forthwith proclaim that every sample of bread they had examined contained some 2 per cent. of alum.

Such errors, however, could hardly have been made by anyone with a knowledge of chemistry.

Among chemists, vide Watts's Dictionary of Chemistry article Bread, a method was in vogue a short time ago, which is generally attributed to Kuhlmann, but which is not very good. The essential feature of the method consisted in boiling the precipitate insoluble in water with some solution of pure caustic potash, or soda, whereby the phosphate of alumina would be dissolved out whilst the phosphates of magnesia and lime are left insoluble. The alkaline solution of phosphate of alumina was subsequently boiled with chloride of ammonium to precipitate the phosphate of alumina which was finally separated by filtration, washed and weighed, and the amount of alum calculated from it.

In practice this method does not answer well, since the comparatively large gelatinous precipitate of mixed phosphates of lime and magnesia retains the phosphate of alumina with great obstinacy, so that it is well-nigh impossible to make a satisfactory determination of alum by the method.

The method which is now adopted, and which is satisfactory, is founded on the difference in behaviour of phosphate of alumina and phosphates of lime and magnesia towards acetic acid. Whilst phosphate of lime and phosphate of magnesia dissolve with great readiness in acetic acid, phosphate of alumina is nearly absolutely insoluble in acetic acid. When the analyst has a mixture of these phosphates, such as is obtained in the course of an analysis of bread-ash, he may treat it with acetic acid which will dissolve the phosphate of lime and phosphate of magnesia and leave the phosphate of alumina insoluble.

The following are the details of the testing for alum, as carried out in our laboratory.

50 grammes of flour or 100 grammes of bread are placed in a platinum dish and ignited over a large Bunsen burner for several hours.

This dish which we are in the habit of using is tolerably stout and weighs about 100 grammes, its capacity when quite full up to the very brim being 200 cubic centims. Before being used the dish is polished with charcoal and weighed with accuracy. During the ignition the Bunsen burner is supplied with an excess of air, so that the dish may be as little as possible attacked by the gas : the ignition is moreover, managed at a moderate temperature.

The ignition is continued until the flour-ash does not exceed one gramme in weight, and the bread-ash two grammes.

That this has been accomplished, is ascertained by cooling the dish on a porcelain tile, or on a slab of polished iron, weighing the dish with its contents, and subtracting the original weight of the dish.

The ash having been obtained, it is then moistened with 3 c.c. of pure strong hydrochloric acid, sp. gr. 1·2, and then some 20 or 30 c.c. of distilled water is added, and the whole is boiled, filtered, and the precipitate washed several times with boiling water. In this manner a precipitate consisting of silica and sand together with some unburnt carbon is left on the filter, whilst the filtrate contains the phosphates. The precipitate, which, after being burnt consists of silica and sand, is weighed. The filtrate is mixed with 5 c.c. of liq. ammoniæ (sp. gr. 0·880) whereby it is rendered powerfully alkaline, and opaque, owing to the precipitation of the phosphates. It is finally mixed gradually with some 20 c.c. of moderately strong acetic acid, and, as the acid is being poured in, the observation may be made that the liquid is alkaline and opaque until some 5 c.c. of acid has been added, that when about 10 c.c. has been added the liquid is acid and much clearer, and that at least 10 c.c. of acetic acid is added after the establishment of a distinctly acid reaction. The liquid is then boiled and filtered, and the precipitate, consisting of phosphates of alumina and iron, well washed with boiling water, ignited, and weighed. The last step is the determination of the iron in the weighed precipitate, and this is accomplished either by reduction and titration with standard solution of permanganate in the well known manner, or else by a colour-process, viz., by titration with ferrocyanide of potassium. In cases where the quantity of iron to be measured is minute, we prefer the colour-process, which will be very

simple and easy of execution to all persons who are familiar with the ammonia-process of water-analysis.

A few words may be devoted to the description of the process. The colour-titration of iron resembles Nesslerising, a weak standard solution of iron being substituted for the standard ammonia, and a solution of ferrocyanide of potassium for the Nessler reagent. The iron solution may be conveniently made by dissolving a gramme of fine iron wire in nitro-hydrochloric acid, precipitating with ammonia, washing the peroxide of iron and dissolving it in a little hydrochloric acid, and diluting accurately to one litre. This gives a standard solution whereof one cubic centimetre contains one milligramme of metallic iron in the condition of perchloride of iron. This standard (just as in the case of ammonia) may be diluted a hundred times to give the dilute iron solution containing $\frac{1}{100}$ milligramme of iron per cubic centimetre. The remainder of the operation closely resembles Nesslerising. The solution to be tested is put into a cylinder of clear colourless glass, and marked at 50 c.c. capacity, 1 or 2 c.c. of solution of ferrocyanide of potassium is added, and after shaking up and standing the depth of colour is observed. That being accomplished an imitation of the colour is made with standard iron and ferrocyanide in another cylinder, and the quantity of iron required for the imitation is the quantity present in the solution under examination. The point of dissimilarity between Nesslerising and this colour-titration is, that whereas Nesslerising takes place in alkaline liquids, this titration requires that the liquid should be considerably acid, and to ensure this every cylinder containing iron-liquids *is first made to receive one cubic centimetre of either concentrated hydrochloric acid, or nitric acid before the addition of the* ferrocyanide of potassium.

We observe in an old number of the CHEMICAL NEWS (vol. xxx., p. 257, December 4, 1874), a description of the testing for iron by this colour-process by T. Carnelley, B.Sc., whose observations on the subject we are able to confirm. In order to apply the titration to the mixed phosphates, it is necessary to dissolve them in acid, and it will be found convenient to dilute the solution accurately to 100 c.c., and to take one-tenth for the colour-titration. Having ascertained the amount of iron in the precipitate of mixed phosphates, it is only necessary to calculate it into phosphate of iron and to subtract the weight of the phosphate of iron from the total weight of the mixed phosphates. The difference is the phosphate of alumina yielded by 50 grammes of the flour, or by 100 grammes of the bread.

So much having been accomplished, another of the difficulties of the subject has to be dealt with. If the reader will refer back a few pages he will perceive that flour and bread-ash themselves yield a small proportion of precipitate insoluble in acetic acid, and this has to be properly allowed for before the detection of alum can be valid.

The usual yield of this precipitate by *100 grammes* of unalumed flour appears to be 0·013 grammes, and of this about 0·005 grammes is phosphate of iron, leaving about 0·008 grammes of phosphate of alumina. Very much the same quantity of phosphate of alumina is yielded by unalumed bread. Before aluming can be considered as proved, a correction to this extent must be applied, and ·008 gramme must be deducted from the phosphate of alumina yielded by the sample.

In practice, as will be understood, the testing for alum in flour or bread comes to this—the question is answered by

experiment, as above described, whether or not the precipitate insoluble in acetic acid given by the ash of 100 grammes of flour or bread exceeds ·018 gramme. If it does *not* the flour or bread is *unalumed*; if it does then, a further investigation, i. e. a titration of the iron is executed, and the amount of phosphate of iron deducted and ·008 grammes also deducted, and the residue, if there be any, may then be calculated into alum.

122 parts of Phosphate of Alumina $Al_2O_3P_2O_5$ correspond to 453 parts of Ammonia-alum, $Al_2\,O_3$, $3\,S\,O_3$, $(N\,H_4)_2O\,S\,O_3$, $24\,H_2\,O$. Or 1·00 parts of the phosphate equal 3·71 parts of alum. Hence the rule, multiply the ppt. by 3·7 and you will get the weight of the alum.

If the analyst have followed the directions above given he will arrive at the percentage of alum in the flour or bread. In the case of bread it is customary to return the results in terms of grains of alum in the 4lb. loaf. To do so, the obvious procedure is to multiply the percentage by 280 which gives the number of grains of alum in 28000 grains of bread, or in 4 lbs.

The following example which occurred in our practice as analyst for the town of Buckingham may be cited—100 grammes of the sample of bread was weighed, to within about a gramme, on a convenient balance, and all of it was put into the platinum dish at once. It was ignited.

Weight of dish and ash	=	100·17	grammes.
,, ,, dish	=	98·40	,,
ash	=	1·77	

The ash was treated with hydrochloric acid, as described, and the insoluble portion, i. e. the sand and silica weighed thus :—

Crucible + Sand and Silica	=	28·190	grammes.
Crucible	=	28·163	„
		·027	
Deduct filter ash	=	·002	
Sand and Silica	=	·025	

And then the filtrate was made to yield the ppt. insoluble in acetic acid, which was weighed thus :—

Crucible + Phosp. of Iron and Alumina		28·214	grammes.
Crucible	=	28·163	„
		·051	

By titration 0·004 gramme of phosphate of iron was found in the ppt. On deducting that and ·008 (for natural phosphate of alumina), there remains ·039 gramme of phosphate of alumina due to alum.

Therefore 40·4 grains of alum in the 4 lb. loaf.

For practical purposes this calculation may be saved, inasmuch as the number of milligrammes of phosphate yielded by 100 grammes of the bread corresponds, with sufficient accuracy, to the number of grains of alum in the 4lb. loaf.

This observation we owe to Mr. Allen, Public Analyst for Sheffield.

As will have been observed, we do not advise an evaporation of the hydrochloric-acid solution to dryness, neither do we advise a fusion of the ash with carbonate of soda. On the contrary, if the object of the analyst be the detection of alum, the performance of these operations will hinder, and not help him.

In the ash of flour and bread there is some silicate of alumina, which did not exist in the grain, but which comes from accidental traces of clay, and from rubbing down of the mill-stone. It is of importance not to dissolve this silicate of alumina, and avoidance of the evaporation to dryness with hydrochloric acid and fusion with carbonate of soda, avoids such solution to a great extent. At the same time it has been most amply proved that, after the ignition, the phosphate of alumina arising from alum in bread remains in a state very easily soluble in hydrochloric acid: so that fusion with carbonate of soda is quite unnecessary for that purpose.

There is no danger of silica passing into solution when the evaporation to dryness is neglected: inasmuch as bread and flour-ash is naturally not alkaline, and direct experiment has moreover shown, that rather less than more "silica and sand" is left insoluble by evaporation to dryness, than without evaporation to dryness.

In the course of his work, the Public Analyst will, every now and then, meet with samples of bread yielding rather more than the usual proportion of silica and sand. Such samples are entitled to yield more ppt. insol. in acetic acid: and about ·002 gramme of this ppt. per ·010 gramme of silica and sand in excess over ·030 grammes per 100 grammes of flour or bread should be allowed.

Thus, when the "silica and sand" in a sample of flour or bread amount to, say ·070 gramme per 100 grammes of flour or bread, an allowance of ·016 gramme of phosphate of alumina (instead of ·008 gramme) should be made before reckoning the phosphate of alumina as indicative of alum.

The Sulphates in Alum.—The formula for Ammonia-alum is

$$Al_2\,O_3,\ 3\,S\,O_3,\ (NH_4)_2\,O\ S\,O_3\ 24\ H_2\,O$$

and on making a calculation it will be found that 1·00 part of Ammonia-alum is equivalent to 1·03 part of Sulphate of Baryta. Approximately, therefore, Alum is represented by its own weight of Sulphate of Baryta, and a very convenient method of measuring the Alum is suggested to the chemist.

Unfortunately, however, great practical difficulties stand in the way.

The ash is absolutely unavailable for this purpose, as may be easily shown. Thus it will be undertood that, on igniting alumed flour, the sulphate of ammonia will be dissipated, and the sulphuric acid in combination with the alumina would be expelled by the excess of phosphoric acid in the ash of flour. All this may obviously be avoided by the employment of carbonate of soda to retain the sulphuric acid : but, when carbonate of soda is mixed with flour or bread previously to ignition, the ash is always found charged with the sulphates arising from the sulphur which is a component of the gluten. Manifestly, therefore, it is futile to resort to the ash of flour or bread with the view of following the sulphates introduced by the alum.

The cold aqueous extract of flour may be resorted to with very partial success. In an experiment in which a specimen of flour had been slightly alumed in the laboratory, about one-half of the sulphuric acid of the alum was obtained in the form of Sulphate of Baryta.

In the case of bread the method is not very practicable, because—either from the salt, or from the yeast, or from some other source—sulphates find their way into bread ; and bread, to which no alum has been added, is sometimes (if not always)

found to contain sulphates.

The Ammonia in Alum.—When the cold aqueous extract of alumed flour or bread is rendered alkaline, and distilled, ammonia passes into the distillate and may be detected, and measured by the Nessler-test. In carrying out this operation in practice, care must be taken not to employ too concentrated a cold aqueous extract. If this precaution be neglected, the liquid will froth over in the retort, but will not distil. But by proper dilution the difficulty may be overcome.

The following method is practised in our laboratory:- 56 grammes of the sample of bread is mixed with 500 c.c. of cold water, which is known to be free from ammonia, the liquid is filtered, one quarter of filtrate, that is to say 125 c.c. of the filtrate, is then diluted with 375 c.c. of water and the resulting half-litre of liquid is introduced into a retort and distilled. Before the distillation is begun a little potash solution is added. The quantity which we employ is 0·25 of grammes.

The distillate is *nesslerised* in the manner which will be familiar to those persons who are acquainted with the "Ammonia process" of water-analysis.

In the operation just described one quarter of 56 grammes of bread is made to yield ammonia.

Our experiments appear to show that 14000 milligrammes of common unalumed bread yields 0·30 milligramme of ammonia. It is therefore only the ammonia over and above the 0·30 milligramme that is to be ascribed to the presence of alum.

If a calculation be made it will be found that one part of ammonia is yielded by 26·6 parts of ammonia alum.

Hence the rule : ——

Multiply the milligrammes of ammonia by 53·2 and the product will be the number of grains of ammonia-alum contained by the 4℔ loaf. Our experience as public analysts leads us to the conclusion that alumed bread is very rare. Out of some 70 specimens of bread, the analysis of which we have before us, only some 3 or 4 specimens are open to suspicion as being alumed. In taking leave of this portion of our subject we have to advise the public analyst to seek confirmation when a suspicious case arises. An accidental mixing of the flour with a minute quantity of clay — 2 or 3 grains of clay to one pound of flour — would simulate aluming to the extent of 30 grains per 4℔ loaf; we would therefore urge on the public analyst that he should seek corroboration by having resort to a testing for ammonia and for sulphates.

Sulphate of Copper has been employed in bread-making with much the same object as alum, and is effective in even smaller proportion than alum.

We consider that this practice should be dealt with the utmost rigour. Fortunately the detection of traces of copper in organic mixtures is exceedingly easy and exceedingly delicate.

With the object of detecting traces of copper in flour or bread, 100 grammes should be incinerated in a platinum vessel, the ash moistened with two or three drops of oil of vitriol, and warmed and let cool. Then a little water should be added and a little piece of clean zinc or iron put into the platinum dish containing the liquid. Bye-and-bye if it be present, copper will be deposited on the surface of the platinum dish in the neighbourhood of the piece of zinc or iron, and may be recognised by its red colour. The liquid may then be poured out of the dish, and the spot of copper dis-

solved in a drop or two of boiling oil of vitriol, diluted and supersaturated with ammonia, when if there were more than the minutest trace of copper the beautiful purple of the amidide of copper would be visible. Ultimately the excess of ammonia may be driven off by gently warming, and a little ferrocyanide of copper may be produced—this last being the most delicate test for copper and being capable of giving an indication of copper when the amidide-reaction fails.

CHAPTER IV

THE GLUTEN ASSAY. THE NITROGENOUS PORTION OF FLOUR: THE YIELD OF ALBUMINOID AMMONIA.

The Gluten Assay.—Weigh out 10·00 grammes of the sample of flour and then place it in a heap in the centre of a glazed white porcelain tile about 7 or 8 inches square. (Such tiles are readily to be bought, and are common in laboratories in London.) Drop, on the flour, 4 cubic centimeters of distilled water, and work the water and flour together with a palette knife until all the flour has been incorporated to form a stiff paste or dough; this should be done neatly, and the dough may be used to mop up the last traces of flour, the knife and the tile being finally cleaned with the lump of dough. In this manner a ball of dough resembling the pill-

mass of the apothecary is the result. A stout cylindrical glass capable of holding 200 cubic centimeters is then selected and the ball of dough is placed in it. About 50 cubic centimeters of water is poured into the glass on to the dough and, by means of the palette knife, the ball of dough is worked up with the water so as to yield up the starch-granules to the water and to leave a sticky mass of gluten. The water in which the starch-granules are suspended is then carefully decanted off, fresh water added and the operation repeated until the gluten ceases practically to give up starch to the water. The resulting mass of gluten is then immersed in ether and worked in the ether by means of a glass rod, and finally, by the aid of the glass rod, it is transferred to a clean platinum dish and by means of the glass rod spread out in a thin layer over the inner surface of the platinum dish so as to be capable of being easily dried. The platinum dish is then heated in the water bath, until its contents cease to lose weight on further drying.

The object of the employment of the ether is two-fold. It extracts a trace of fatty matter (which however experiment has shown to be very trifling in amount), and it has a mechanical use, inasmuch as it partially dries the gluten and enable us to spread out the gluten in a very thin layer on the surface of the platinum dish.

The decanted aqueous liquid deposits a layer of starch granules, and an examination of this deposit should be made in order to make sure that no gluten has been mechanically washed away. In cases of great importance resort might even be had to an examination of the starch by means of the ammonia-process.

The thoroughly dried gluten having been weighed, a correction for ash and for fat should be made.

The correction for ash is 0·3 per cent on the flour.

The correction for fat is 1·0 on the flour.

Very concordant results may be obtained if the foregoing directions be followed. The following will serve in illustration :

Experiment I.—10·00 grammes of a sample of Biscuit flour was submitted to the treatment just described, the resulting mass of gluten being spread out in a thin layer over the inner surface of a platinum dish, which together with its contents was dried in the water-bath, at 212° Fah, until no further loss of weight occurred :—

		grammes.
Weight of Gluten and Dish	=	96·801
,, ,, Empty Dish	=	95·332
		1·469

Multiplying by 10, and subtracting 1·3, the correction for fat and ash, we have :—

	14·69
less	1·30
	13.39

which is the percentage of gluten in the sample of flour.

Experiment II.—on the same sample of flour, gave 13·65 as the percentage of gluten. This flour is rich, perhaps exceptionally rich. Another kind of flour, bought at a baker's shop in Westminster, yielded less gluten, viz., 11·5 per cent.

When flour is not perfectly sound, when it is adulterated

(It will hardly be necessary to add that, in any given case, the analyst may make a special determination of the ash by ignition, and of the fat by boiling the *powdered* dry gluten with ether and evaporating down the resulting ethereal solution and weighing the dried-up residue of fat.)

and when it is naturally poor in quality, the yield of gluten is diminished. One of the best—if not the very best criterion of the genuineness of flour, is that it should give a proper yield of gluten. Not only should the quantity of the gluten be satisfactory, but the quality of the gluten in its hydrated condition should be good.

For the purpose of ascertaining the mechanical quality of the hydrated gluten a fresh quantity of flour may be converted into dough and washed in the manner described—only the immersion in ether should be omitted. The hydrated gluten should be sufficiently ductile.

The nitrogenous portion of the flour comprises the soluble vegetable albumen in addition of the gluten; and the soluble vegetable albumen amounts about to 1 per cent of the flour.

For many purposes a determination of the total nitrogenous substances in flour is required. When that is the case the ammonia-process may be resorted to: and we will here quote a paper published by ourselves in the Philosophical Magazine in May, 1877.

"The physiological doctrine that the animal does not produce proteine compounds, but simply transforms those proteine substances which it has taken in as food, lends great importance to the determination of the amount of proteine compounds in different kinds of vegetable food; and such a determination becomes of the utmost importance both to the physiologist and from a practical point of view.

Hitherto, however, this desideratum has been very imperfectly supplied, and the chemist has very inadequately answered the question as to the proteine value of the different vegetable foods. Gluten, legumen, vegetable caseine, vegetable albumen, as the various proteine substances occurr-

ing in vegetables have been called, vary much in properties. Some of them are soluble and others are insoluble in water; and some of them are soluble in alcohol; and it would be difficult to draw up any general method of extracting the proteine compound in a state of purity. Resort has therefore been had to elementary analysis; and chemists have deduced the amount of proteine compounds from the percentage of nitrogen found on submitting the food to ultimate analysis.

To this procedure there are several objections which have, apparently, not been sufficiently insisted upon. Taking the case of wheaten flour (which is much more favourable than many other cases), the percentage of nitrogen is about 2·00; yet neither the Will-and-Varrentrapp process nor the Dumas process of nitrogen-determination, as it is generally carried out, is at all adequate to the valuation of the proteine sub-subtance in flour.

The Will-and-Varrentrapp process, as those who have a critical knowledge of it are aware, is subject to special failure when it is applied to proteine substances, and is not a determination of nitrogen in these instances.

The Dumas method, as usually practised, is uncertain when it is applied to determine a minute quantity of nitrogenous substance in presence of a large quantity of non-nitrogenous organic matter. Possibly, if carried out with extraordinary care and extraordinary precautions, the Dumas process might become available for the process in view but those persons who have practical knowledge of the difficulties besetting this particular case will admit that extraordinary care would indeed be required, and that the process would be too impracticable for general employment.

The method by which we seek to accomplish the task

before us is, we believe, specially adapted for this description of work.

We propose to measure the amount of proteine substances in vegetables by the amount of ammonia which the vegetables *generate* when they are subjected to the action of a boiling solution of potash and permanganate of potash; in fact, we have made a special adaptation of the well-known ammonia process of water-analysis to the case of vegetable proteine.

The working details of our process are as follows:—

Into a litre flask a carefully weighed gramme of the vegetable substance to be analysed is placed, and 20 cub. centims. of *normal solution of caustic potash is added, and then water is added until the litre-mark is reached by the level of the liquid. The contents of the flask are then shaken up so as to ensure thorough mixture. In this manner we obtain a liquid of such a strength that each cubic centim. contains one milligramme of the flour or other vegetable substance to be operated upon. 10 or 20 cub. centims. of this liquid (*i.e.* 10 or 20 milligrammes of the vegetable substance) are convenient quantities to work with.

The next step is to get the retort in order, as for a water-analysis, and to place in it 300 or 500 cub. centims. of good drinking-water, and to add 50 cub. centims. of a solution containing 10 grms. of potash and 0·4 grm. of permanganate of potash (such as is used in water-analysis), and to distil until the residue in the retort no longer yields the slightest trace of ammonia That having been done, 10 or 20 cub. centims. of the liquid containing the vegetable substance are to be added and the distillation proceeded with. The vegetable

* Solution of potash made by dissolving 5 grammes of solid sticks of potash in 100 cubic centimeters of water will answer.

substance will then be attacked, and its proteine will yield ammonia, which will distil over and may be measured by means of the Nessler test. For further details of the manner of carrying out work of this description we would refer to the Treatise on Water-analysis, which is now sufficiently well known to chemists.

It was shown, some years ago, that egg-albumen yields about one-tenth of its weight of ammonia when submitted to such a process as the above, and that solutions containing different quantities of egg-albumen yield ammonia exactly proportional in amount to the strength of the solutions of albumen.

As will be observed, our present experiments include many descriptions of wheaten flour, also pea-, rice-, maize-flour, oats, barley, malt, rye, and arrowroot. The last-named is important as showing a very small proportion of proteine.

The pea-flour was ground from the peas in our own laboratory, and passed through a very fine sieve. The rice-flour was likewise of home-manufacture; and the same is true of maize and the malt. The rest were not powdered in the laboratory.

From sixteen samples of wheaten flour we obtained:—

	Name of sample.	Percentage of ammonia.
1.	Cambridgeshire extra-superfine......	1·10
2.	Another sample ,, ...	1·00
3.	Household flour, Waterloo Bridge...	1·13
4.	Country flour...........................	1·08
5.	Huntingdonshire......	1·05
6.	Suffolk.................	1·00
7.	Hungarian......	1·10

	Name of sample.	Percentage of Ammonia.
8.	Another Hungarian	1·05
9.	,, ,,	1·07
10.	Darblay, Paris	1·05
11.	Vienna	1·08
12.	Australian	0·92
13.	Californian	1·13
14.	American	1·14
15.	Another American	1·17
16.	,, ,,	1·09

From the other nitrogenous substances we obtained :—

Name of sample.	Percentage of Ammonia.
Pea-flour	2·30
Rice- ,,	0·62
Maize,,	1·03
Oats	1·00
Barley	1·10
Malt	0·50
Rye	1·45
Arrowroot	0·08

In looking through these Tables the reader will be struck with the constancy of the quantity of proteine substances in wheaten flour. If one of the American samples (No. 15) be excluded (possibly there was a little pea-flour in that sample), it will be seen that the highest percentage of ammonia given by any sample of flour is 1·14 ; and, excluding the solitary sample of Australian flour, the lowest yield of ammonia is 1·00. Wheaten flour would therefore seem to yield between 1·00 and 1·13 per cent. of its weight of ammonia when subjected to the above process.

Maize, oats, and barley, as will be seen, very closely resemble wheaten flour in yield of albuminoid ammonia. Rye, on the other hand, is exceptionally rich in proteine, apparently it is the most nitrogenous cereal.

The high percentage of ammonia from pea-flour will attract attention. The proteine in rice amounts to about half as much as in wheaten flour.

CHAPTER V.

THE COLD AQUEOUS EXTRACT: SOUND AND UNSOUND FLOUR.

By far the larger part of flour is insoluble in cold water. Thus, the 64·8 per cent. of Starch-granules, the 12·0 per cent. of Gluten, the Fat and a portion of the Ash are insoluble in cold water; whilst the 3·5 per cent. of Modified Starch, the 1·0 per cent. of Vegetable Albumen, and the soluble part of the Ash constitute the soluble portion of the flour, and pass into solution when submitted to the action of cold water. When such a solution in cold water is evaporated to dryness at 212° Fah. a residue is left, and that dried residue is "The cold aqueous extract of flour."

The amount of "The cold aqueous extract" given by a sample of flour is worthy of the attention of the analyst, and, as will presently be seen, is readily ascertained.

If the starch-granules in a sample of flour have been injured either chemically or mechanically, then the cold aqueous extract may be expected to be too large: and, therefore, the circumstance that the cold aqueous extract from a given sample of flour either is normal in amount, or is not normal, becomes a valuable indication.

The quantity of cold aqueous extract given by a sample of flour is ascertained in the following manner.

One hundred grammes of the flour are weighed out and then gradually stirred up with distilled water in a large porcelain basin and the whole mixture is placed in a litre-measure and diluted with water up to the litre-mark on the flask. The contents of the litre-flask are next poured into a beaker, in order to ensure thorough mixing, and afterwards they are poured on a large filter and the clear filtrate allowed to filter through. The first small quantity of filtrate having been rejected, 50 c.c. of the filtrate are collected and accurately measured, and then evaporated to dryness in a platinum dish placed in the water-bath. Finally the dish, with dry residue adherent to it, is weighed and the weight of the empty dish subtracted from the total weight, and so the weight of the dry residue is arrived at.

As will have been observed, 100 grammes of flour were directed to be taken in the above operation, but only one-twentieth of the resulting solution was to be evaporated to dryness. The weight of the dry residue must, therefore, be multiplied by 20 in order to give the quantity of extract furnished by 100 grammes of the flour.

The following examples, wherein the extraction has been made in slightly different ways — where, for instance, sometimes the flour has been treated with 5 times its weight of water, sometime with 10 times, and sometimes with 20 times, and where the sample of flour has likewise been varied — show that fairly constant results are attainable.

100 grammes of flour yielded:—

A	4·69	grammes of dry extract
B	5·12	" "
C	5·18	" "
D	4·68	" "
E	5·45	" "
F	4·94	" "
G	4·78	" "
	34·84	
mean ...	4·98	

Sound flour, therefore, yields about 5 per cent. of its weight of cold aqueous extract dry at 212° Fah.

We have already indicated the constituents of flour which go to form the cold aqueous extract. They are the modified starch, the vegetable albumen, and a part of the ash. Concerning the modified starch we have to remark that, although the dry flour may possibly contain soluble starch from broken granules, there can be no soluble starch in the cold aqueous extract; inasmuch as, so soon as water is added to the flour, the action of the vegetable albumen is set up, and any soluble starch that may be present in the flour is forthwith resolved into maltose and dextrine.

The presence of the maltose is indicated by the reduction of oxide of copper to red suboxide, and the amount of the

maltose may be measured by adopting the method recommended by O'Sullivan. For this purpose a measured quantity of solution of the cold aqueous extract is mixed with an excess of Fehling's solution (which is a solution made by dissolving sulphate of copper in water and adding to it potash and tartrates of potash and soda) and heated to the boiling point of water, whereupon a precipitate of red suboxide of copper is formed.

The precipitated suboxide of copper is washed, placed on filter paper and then dried and ignited and weighed. During the ignition the red suboxide is converted into black oxide of copper. The amount of oxide of copper multiplied by 0·75 gives the amount of maltose yielded by the cold aqueous extract.

The vegetable albumen in the cold aqueous extract is coagulated on heating the solution to the boiling point of water. The amount of vegetable albumen may be measured either by the ammonia-process (vide Chapter IV), or else by boiling a measured quantity of solution of cold aqueous extract, filtering to remove the coagulated vegetable albumen, and then evaporating the filtrate to dryness and weighing the dried residue. The difference between the total weight of the cold aqueous extract, and the weight of the residue obtained after removing the coagulated albumen, is the weight of the vegetable albumen in the cold aqueous extract.

The amount of the ash is ascertained by igniting the cold aqueous extract and weighing the residue. The ash, which consists mainly of phosphate of potash, amounts to 0·4.

The following is the composition of the cold aqueous extract obtained from 100 grammes of a sample of flour :—

		grammes.
Maltose, Dextrine &c.	...	3·33
Vegetable Albumen	...	0·92
Ash	...	0·44
Total cold aqueous extract		4·69

The quantity of Maltose in the cold aqueous extract, from 100 grammes of flour has been measured by the copper test &c., about 1·2 grammes, The small amount of Maltose is worthy of attention since it is the fermentation of the Maltose which causes the rising of the bread in the ordinary process of bread-making.

The latest researches have shown that the Dextrine does not suffer fermentation, and the quantity of Maltose in the cold aqueous extract limits the possible amount of carbonic acid generated during the rising of the bread.

This consideration will render obvious the utility of adding a little gelatinised starch to the dough in order to lighten the bread, and with this object in view the addition of a little gelatinised potato-starch is often recommended.

The cold aqueous extract of Bread.—This differs from the extract of flour. There is a quantity of common salt in bread, and hence the extract of bread contains salt ; and the ash is much higher than the ash of the extract of flour.

But the most striking peculiarity of the cold aqueous extract of bread is that it contains soluble starch, and consequently strikes a beautiful blue on the addition of iodine.

How it happens that extract of bread should contain soluble starch, whilst extract of flour does not, will be quite

intelligible. Bread, when it is baked, loses the soluble and fermentative albumen, which is rendered insoluble and inactive: and hence the starch granules which are burst in the operation of baking are not exposed to any ferment and the soluble starch is enabled to pass intact into the cold aqueous extract of bread. We have already (vide Chapter I.) mentioned that only a comparatively small proportion of the starch-granules are ruptured during the baking of bread, as ordinarily practised.

Sound and unsound flour. As we have already said, in cases of great illtreatment of the starch granules we should look for a very increased cold aqueous extract; but in cases of incipient unsoundness of flour, we do not look for any marked increase in the extract.

We believe that the first indications of unsoundness are shown by the quality of the gluten which has its tenacity and ductility impaired; and, in connection with the question of unsoundness, we would call attention to the very low yield of albuminoid ammonia from malt (vide Chapter IV.) which we should take to be typical of that which characterises unsound flour. We make a suggestion based on an experiment made in the laboratory. Accompanying the change in the nitrogenous portions of the flour we should expect modification of the soluble starch; and accordingly unsound flour should be distinguished by the entire absence of soluble starch from the dry flour, whilst sound flour should contain traces of soluble starch. In the experiment to which we refer we found a much larger proportion of maltose in the cold *aqueous* extract than in the cold *alcoholic* extract of the same flour.

The maltose we measured by means of the quantity of oxide of copper which had been reduced.

Our suggestion is, that unsoundness in flour should be indicated by the presence of an increased amount of maltose in the *alcoholic* extract of flour.

CHAPTER VI.

ON FOOD.

In early infancy a single natural product, viz. milk, suffices, altogether, for the dietetic requirements of the human being, and at that period, constitutes the complete dietary. But later on in life, milk ceases to satisfy, and,—though it may enter into the dietary,—it cannot constitute the complete dietary of the full-grown man.

There is no single product which occupies exactly the same place in relation to the adult as milk in relation to the young child.

From this point of view, the nearest representative of milk is bread, or rather bread and water, which is prison diet, being

meagre fare, which may indeed sustain life for considerable periods, but does not maintain the human frame in a state of vigour and efficiency.

There is a peculiarly chemical aspect of the question to which we will now direct the attention of our readers.

It is well known that, after attaining to adult age, the human body is usually maintained at very nearly the same weight for many years. Since thus there is neither gain nor loss, is follows as a necessary consequence, that the weight of the average daily food must be the weight of the average daily *excreta*, understanding, of course, by *excreta* the total excreta ; that is to say including the carbonic acid passing off during respiration as well as the products of the activity of the kidneys, and other excreta. Physiological chemists have measured this total in terms of carbon and nitrogen, and the received physiological datum is as follows:—

The adult man requires, when in perfect health and activity, 4500 grains of carbon and 300 grains of nitrogen, daily, in the shape of food.

Given, therefore, a dietary for an adult, the first question that presents itself is,—are these conditions complied with?—does the day's ration contain 4500 grains of carbon, and 300 grains of nitrogen? The further question will afterwards arise—are these quantities of carbon and nitrogen in suitable and assimilable forms?

With these considerations present to our minds, let us now investigate milk supposed for the moment, to be a complete dietary for the adult.

Referring to the Treatise on Milk-Analysis we find that 100 c.c. of Country milk of good average quality contains :—

	Grammes.		C.	H	N	O
Water - -	90·09					
Fat - - -	3·16	=	2·442	·375		·343
Caseine - -	4·16	=	2·234	·295	·653	·978
Milk-Sugar-	4·76	=	1·904	·317		2·538
Ash - - -	0·73					
	102·90		6·580	·987	·653	3·859

or 100 c.c. contains :—

Water ...	90·090	grammes.
Carbon ...	6·580	,,
Hydrogen ...	0·987	,,
Nitrogen ...	0·653	,,
Oxygen ...	3·859	,,
Ash ...	0·731	,,
	102·900	

We observe that the ratio of the carbon to the nitrogen in milk is almost exactly

10 : 1

and that, if sufficient milk were to be taken in order to furnish 4500 grains of carbon, there would be an excess of nitrogen. The quantity of milk which contains 4,500 grains of carbon will be found to contain about 450 grains of nitrogen. An exclusively milk diet is, therefore, very largely surcharged with nitrogenous matter. There is another obvious objection to a diet of absolute milk, viz: that it is too bulky. On making the calculation it will be found that as much as about one gallon of milk would be required in order to yield the 4,500 grains of carbon. Thus, the healthy adult

man, who should do a hard day's work on a diet of milk alone, would be burdened with about double the proper quantity of liquid. It is needless to add that such a dietary could not be persisted in for any lengthened period. The attempt to persist in such a dietary would be rewarded by a grevious attack of indigestion which would be accompanied by intense loathing so as to render the further taking of milk an impossibility.

Next let us turn to the bread dietary. In Chapter I, there is a tabular statement of the ultimate, or elementary composition of fine wheaten flour, which we quote.—

Carbon	...	38·350
Hydrogen	...	7·194
Nitrogen	...	2·080
Oxygen	...	51·675
Ash ...	...	0·701
		100·000

The ratio of carbon to nitrogen in flour, or in bread, is

18 : 1

Here then the carbon is in slight excess; and the adult who would take the 300 grains of nitrogen in the shape of bread would take rather more carbon than required.

About 19,000 grains (2lbs. 11oz.) of bread, in its ordinary state of moisture, are required to furnish the 300 grains of nitrogen.

The reason why bread and water does not form a dietary which is capable of sustaining the human frame in vigour and efficiency is the almost entire absence of fat. By the addition of butter, dripping, fat bacon, cheese, &c., the bread diet is rectified. Even gruel, (which is made of oatmeal, the

fattest of grain) is calculated to mitigate the rigour of the bread and water dietary.

This leads us to remark that every complete dietary must not only contain the requisite quantities of carbon and nitrogen, but it must contain those elements in suitable and assimilable condition. We require :—

Fat
Carbohydrates
Albuminoids
Condiments

together with certain mineral matters.

Fat.—It is now generally admitted that no dietary can possibly sustain, a man in vigour, under active exertion, unless it contains some fat. The minimum of fat which is requisite is not known with accuracy ; about 1,500 grains of fat per diem is cited, by some authorities, as a fair average allowance for a full grown man in active exercise. As to the exact form under which the fat occurs in various dietaries we have to remark that it varies greatly. Butter, dripping, bacon fat and lard, suet, and the general fat diffused through flesh meat afford common examples of the forms of animal fat which occur in different dietaries. Olive oil (which, as is well known, is consumed as salad oil), Cocoa butter which is the natural vegetable fat existing in cocoa, and even the fat of oat-meal exemplify common forms of vegetable fat. So far as we know, no preference should be given to vegetable over animal fat, or vice versa.

Carbohydrates.—Starch is the most important carbohydrate. Next to water there is no single chemical substance—no single chemical compound—which is so largely consumed by the human race as starch. The commonest form of starch in

food is the intact starch granule. In a former chapter we have carefully pointed out the peculiarities of the intact starch-granule, which is singularly inert. It is not attacked by malt extract, and is no doubt fitted by this very inertness for the important place which it occupies in so many dietaries.

Text books of Physiology are somewhat confused in their account of the digestion of starch. According to some authors the intact starch-granule is hardly digestible, and passes unchanged along the intestinal canal. But that cannot be accurate : and the truth is, that the digestion of the starch-granule is slow and deferred. Apparently, the digestion of starch begins in the mouth, is arrested in the stomach, and recommences after the food travels along the intestinal tube. Inasmuch as nutrition does not take place until the food has passed through the walls of the stomach, or intestines, and has been absorbed, we can understand that the inertness of starch-granules renders them specially sustaining. Such food becomes active several hours after it has been eaten, and thus continuous nutrition is compatible with intermittent feeding.

One of the most striking differences between the food of the young infant and the food of the adult depends on starch. The infant cannot tolerate intact starch-granules in its food ; but, in the dietary of the adult, intact starch-granules play the important part which we have described.

Most probably some delicate forms of cellulose have much the same dietetic properties as starch-granules. But the grosser forms of cellulose, such as woody fibre, are absolutely inert and useless as food. They pass away unchanged.

When starch-granules are heated with water up to the boiling point of the water they gelatinize and form starch paste.

Starch in that condition is no longer resistant and inactive, but, on the contrary, is eminently susceptible of transformation.

The diet of the young infant should not contain starch except in the gelatinised, or soluble condition. The diet of the adult, although properly containing a large proportion of starch in the form of granule, is improved by the presence of some soluble starch or other soluble carbohydrate.

Among the other forms of carbohydrate occurring in various dietaries we may mention dextrine, maltose, and grape sugar (which are products of the metamorphosis of starch), also gum, cane sugar and milk sugar.

Albuminoids.—The 300 grains of nitrogen in the normal daily ration must exist in the shape of an albuminoid, otherwise they are not valid for dietetic purposes. The albuminoids form a class of substances which have many striking properties in common, but present numerous minor differences. We may enumerate the following albuminoids—Fibrine under its various modifications such as occurs in blood and muscle; albumen which is found in the egg and in the serum of the blood and in other animal fluids; caseine which is found in milk and in cheese; gluten, vegetable albumen, legumen and vegetable caseine.

There is no reason to think that the animal varieties of albuminoids are more nutritious or assimilable than the vegetable albuminoids.

Before the albuminoids taken as food can become available for the nutrition of the human body they have to undergo profound changes. By the action of the gastric juice in the

stomach they are digested, their structure being broken down and their substance made to pass into perfect solution. Not only are they mechanically altered, but they undergo great chemical changes being transformed into peptones, and in that shape, passing through the walls of the blood-vessels and entering into the circulation. Albuminoids, and the peptones resulting from them, differ very widely. The albuminoid has a very large molcular weight and is a highly colloidal body. The peptone must have a much smaller molecular weight inas much as it is diffusible.

Condiments.—Under the heading of condiments and stimulants we may enumerate the meat-extract known as Liebig's Extract, the various pleasant flavouring materials arising from the action of heat on flesh meat, pleasant vegetable flavouring substances, as well as pepper, mustard, and spices.

These substances contribute in an indirect manner towards the nutrition of the body. Food, as has been pointed out, does not nourish so long as it remains in the stomach or intestines, but only after absorption; and the manner in which condiments and stimulants contributes towards nutrition is by promoting digestion and absorption. As a rule very minute quantities of these substances are required in order to accomplish their work, and larger quantities act in a contrary sense.

Under the heading of stimulants, useful in aiding digestion, we ought not to omit to name the commonest of all, viz., alcohol, which plays a two-fold part, and in addition to being a stimulant, is a heat-giving food, ranking with sugar and the other carbohydrates.

Mineral Substances.—There is one mineral substance which we require in considerable quantities, viz., common salt, chloride of sodium. The blood is rich in salt, and a deficiency of salt in that fluid would entail serious consequences.

Apparently the quantity of salt demanded daily is about 200 grains. The symptoms of salt-famine are very little known: but it is obvious, that, if salt were rigidly excluded from the dietary, a fatal result would be inevitable after a while.

Next to common salt comes potash-salts, deficiency of which is said to cause scurvy.

The other mineral substance, necessary to our nutrition, are required in comparatively small quantities, and rigid exclusion of all other mineral substance from the dietary would produce no immediate effect, and would only make itself felt after the lapse of a considerable time.

In order that the bones may be strong and capable of maintaining their natural shape, there is need of a certain quantity of phosphate of lime. This phosphate of lime must be provided by the food. Early in life during the period of growth—there ought to be a proper supply of phosphate of lime in the food. Such a supply is found in milk, which moreover contains the phosphate of lime in a state of chemical combination with caseine, in a form eminently suitable for assimilation. Flesh-meat likewise contains phosphate of lime. Fish also contains phosphate of lime.

The production of bone is a very slow and gradual process, and a very small proportion of phosphate of lime introduced into the dietary of a growing child is capable of making the difference between deformity and proper developement.

We call to mind the example of a well-known public benefactor who used to provide a number of poor children with a dinner of flesh-meat once a week. It is highly probable that the single flesh-meal per week, in many of these instances, made the difference between deformity and proper growth.

After the period of maturity has been reached the demand for phosphate of lime is diminished; and even absolute deprival of food containing phosphate of lime, provided that in all other respects the food were satisfactorily could not produce any sensible effect except after a very long period.

If the reader will turn to Chapter I, and look at the analysis of the ash of fine wheaten flour, he will observe that it contains very little phosphate of lime. Phosphate of potash is there, but phosphate of lime is present in very small proportion; and no doubt part of the phosphate of lime is in an unavailable condition.

Attention has often been called to this deficiency of bone-forming material in fine wheaten flour and fine wheaten bread, and the very curious suggestion has been made that the deficiency of bone-forming material in fine wheaten bread might be rectified resorting to bread made of the whole grain, or "whole meal" as it has been termed.

The percentage of ash in the whole grain is much higher than in the flour, the figures being 1·8 and 0·7 respectively. On this basis the statement has been made that whole meal contains considerably more bone forming mineral matter than is present in the fine flour.

The following analysis of the whole ash of the grain by Gilbert and Lawes shows that there is very little phosphate of lime.

Potash	29·35
Soda	1·1
Lime	3·4
Magnesia	10·7
Phosphate of Iron & Alumina	2·4
Silica	2·5
Phosphoric Acid	49·7
Chlorine	0·13
	99·28

The futility of the resort to whole-meal in order that bone-forming material may be administered, is manifest.

In closing this Chapter on Food we have to add that there yet remains a material which ought to be termed food, inasmuch as it enters into the composition of the body and indeed constitutes by far the largest part of it. That material is water, which forms more than two-thirds of the living man is continually passing away and requires frequent renewal.

Far more water than anything else, is taken into the body. The average quantity of water taken daily by a man is stated to be $4\frac{1}{2}$ lbs. Much of this water is taken imperceptibly and under various disguises. No article of food is absolutely devoid of water. We have called special attention to the water which is present in bread.

Deprivation of water is far more distressing and far more rapidly fatal than deprivation of food generally.

CHAPTER VII.

ON CORN FLOUR.

We have pointed out the great importance of starch as a food. There is in Commerce a very useful class of preparations known as Corn Flour. These consist of almost absolutely pure starch-granules, the purer they are the better they answer the object for which they are designed.

We have made an analysis of Colman's British Corn Flour from the Carrow Works at Norwich. This is an excellent specimen of Corn Flour. It contains:

Starch-Granules	86·59
Water (of Hydration)	13·17
Ash	0·24
	100·00

This Corn Flour was found to be singularly free from nitrogenous matter. From 100 parts of the Corn Flour not more than 0·03 parts of albuminoid ammonia was obtained: which shows that the process of manufacture has been very successfully carried out.

Common wheaten flour, as will be remembered, yields some 1·01 per cent. of albuminoid ammonia which is in striking contrast with the low figure for corn flour.

The difference between common flour and corn flour is brought out by an examination of the "cold aqueous extract," common flour, vide Chapter V, yields, on an average, 5 per cent. of "cold aqueous extract."

The sample of Corn Flour yielded 0·64 per cent. of "cold aqueous extract."

Corn Flour, as might be inferred from its composition, is admirably adapted for keeping.

The methods of preparing corn flour for use as food are sufficiently well known. It is gelatinised in contact with aqueous fluids by being gradually heated—being stirred all the while—up to the boiling point of water.

We have showed that milk—that is to say Cow's milk, is considerably too nitrogenous to constitute the complete dietary of the adult. It is possible that the child may tolerate a more nitrogenous dietary than the adult: but even for the child, Cow's milk is too nitrogenous and requires supplementing by some suitable carbohydrate.

For this purpose Corn Flour, in a properly gelatinised condition, is admirably adapted. The objections which apply to bread and milk do not apply to gelatinised corn flour and milk, which forms a dietary adapted to the wants of invalids and very young children.

In conclusion some notice ought to be taken of the irrational attempts which have, from time to time, been made to disparage Corn flour. The basis of these objections is that Corn flour does not *per se* constitute a complete dietary ; and this fact is shadowed forth in the absurd statement that Corn flour is "not nutritious." With just as much reason might butter or sugar be styled "not nutritious." We hope that this book will tend to deprive such misrepresentations of their power of working mischief.

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